DIRECTED SELF-ASSEMBLY OF MAGNETITE THROUGH ELECTROSPINNING WITH POTENTIAL APPLICATIONS IN NANOPATTERNING

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Introduction

Electrospinning is a unique method for producing micro and nano sized polymeric nanofibers consisting of high surface area, porosity and flexibility. It can further be utilized for producing nano-patterns in applications such as biosensors, magnetic recording and bioelectronics. Magnetite (Fe_3O_4) from the spinel group is the most magnetically natural mineral found on earth and it has been successfully used as a catalyst for the growth of carbon nanotubes (CNTs). This work focuses on a consistent synthesis of magnetite nanopatterns for selective growth of CNTs for potential applications in bioelectronics.

Methods

Electrospinning Parameters:

- Distance (from the needle to the collector) was varied in the steps of 2cm between 11cm and 23cm.
- Supply voltage was kept constant at 15kV.
- Flow rate was kept constant at 1.5ml/h.
- Rotational speed of the collector was kept constant at 1500 rpm.

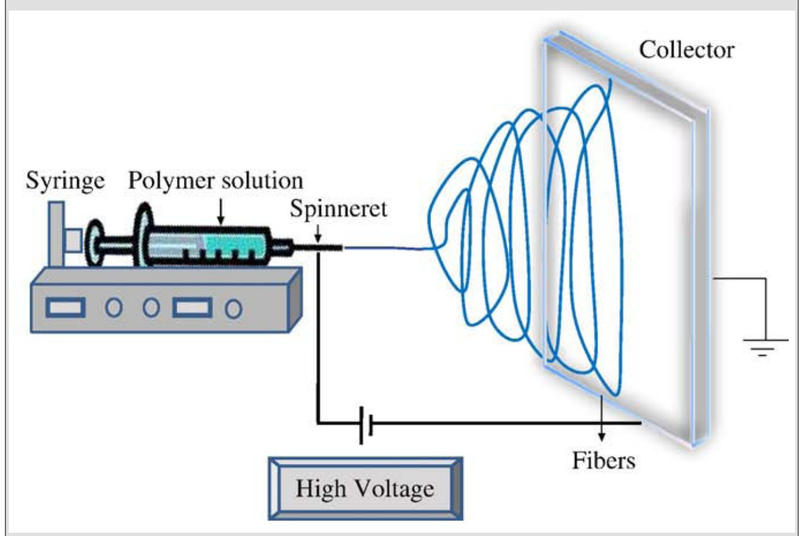
Materials:

- Solvents for magnetite such as acetic acid, distilled water, ethanol, acetone, HCL were used (acetic acid was seen to be the best solvent).
- Synthetic magnetite nanoparticles of 50 – 100nm in size.
- Biomineralized magnetite from Magnetospirillum *magneticum*
- Substrate materials: Aluminum foil, polyethylene, aluminum stubs and glass slides.

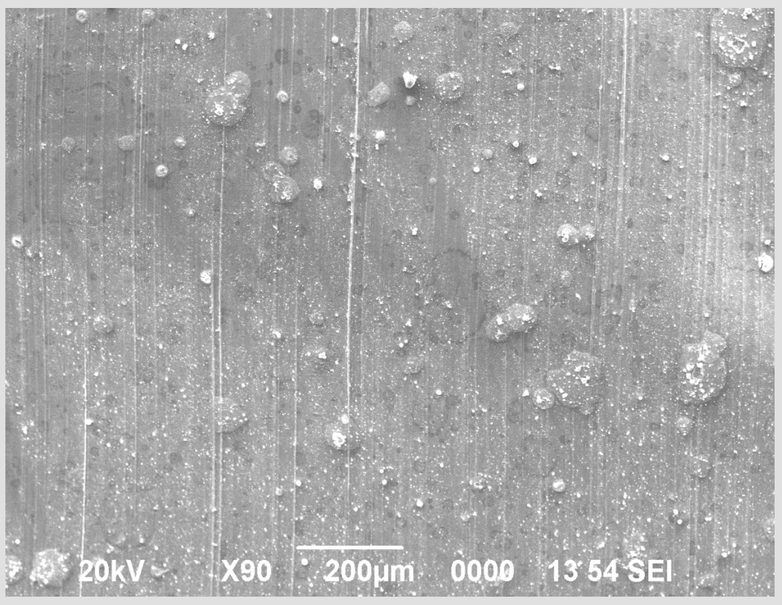
Tools:

- Electrospinning setup with rotating disc type collector
- Scanning Electron Microscope
- Atomic Force Microscope
- Transmission Electron Microscope

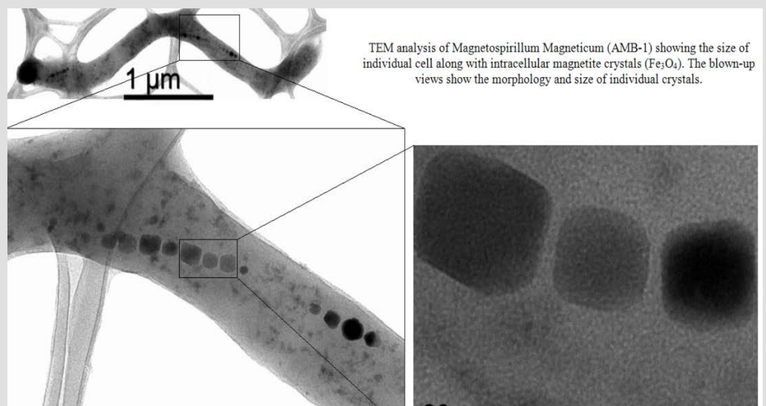
Results



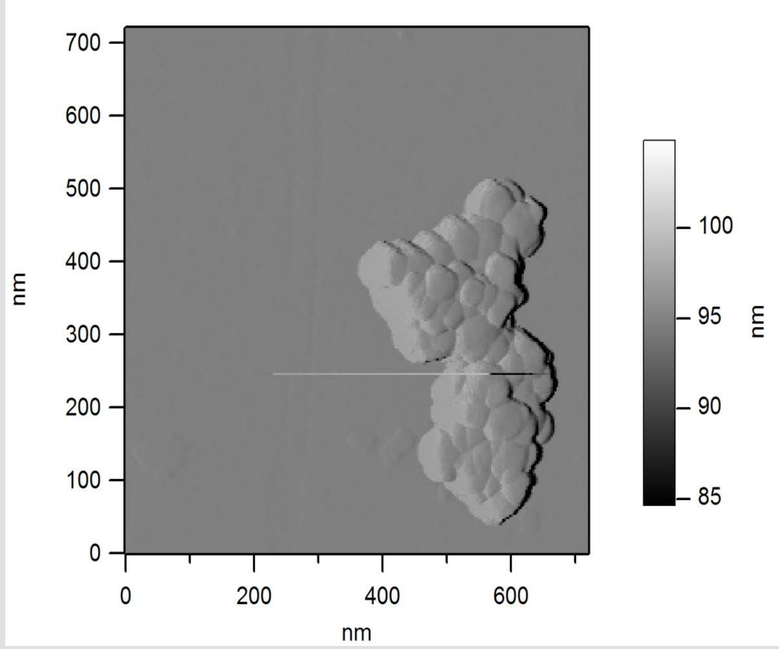
Electrospinning Setup



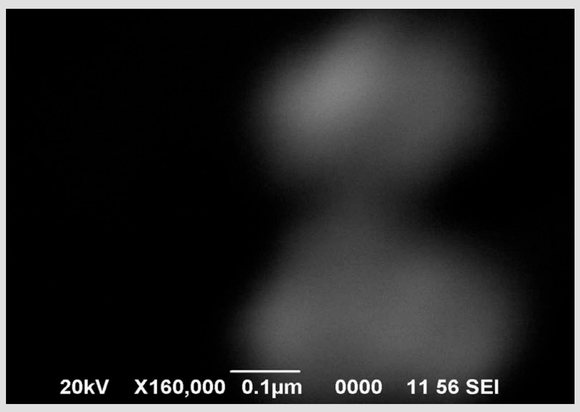
SEM of synthetic Fe_2O_3 nanoparticles with dimensions in the range of 50 – 100nm



TEM image of Fe_3O_4 nanoparticles in AMB-1 with dimensions in the range of 30 – 40nm



AFM of Fe_3O_4 synthetic nanoparticles with dimensions in the range of 25 – 50nm



SEM of individual Fe_3O_4 synthetic nanoparticles

Results

- 0.3g Synthetic Fe_3O_4 dispersed into 10ml Acetic acid electrospun for 2 hours showed dark brown depostions.
- 0.3g Synthetic Fe_3O_4 dispersed into 10ml acetone and sonicated for 15mins. The black powder still remained in beaker.
- 0.3g Synthetic Fe_3O_4 dispersed into 10ml 95% ethanol and the black powder still remained in beaker.
- 0.3g Synthetic Fe_3O_4 dispersed into 10ml HCL and electrospun for 2 hours showed yellow patterns of magnetite on the aluminum substrate.
- 0.3g Synthetic Fe_3O_4 dispersed into 10ml Acetic acid and sonicated for 15 mins and electrospun for 2 hours showed dark brown depositions but bigger chunks of magnetite.
- 0.2g Synthetic Fe_3O_4 dispersed into 10ml Acetic acid and electrospun for 2 hours showed brown depositions with smaller chunks.
- 0.1g Synthetic Fe_3O_4 dispersed into 10ml Acetic acid and electrospun for 2 hours showed light brown equidistant lines with least agglomerations of magnetite.

Conclusion

- In this research, for creating controlled nanopatterns, a novel technique using electrospinning of magnetite nanoparticles is being investigated, where nanopatterns of synthetic as well as biologically sequestered magnetite are proposed.
- This technique can used as a fine control of the fiber diameters, the production of a defect-free or defect-controllable fiber surface, and the formation of continuous single nanofibers. Furthermore, applications such as selective carbon nanotube growth and magnetic storage are some of the potential fields of the future that can be directly influenced by the selective nanopatterning of the magnetite over varying substrates including aluminum, glass and polymers to name a few.

References

[1] Macwan, I., Zhao, Z., Sobh, O., Rho, J., Mahmood, A., Patra, P., 2014. Magnetotaxis as a Means for Nanofabrication. Int. J. High Speed Electron. Syst. 23, 1450008.

[2] Aphale A, Mahakalkar K, Macwan I, Mukerji I, Cox P, Mahapatra M, Singh P, Ajayan P, Patra P, Fabrication and experimental analysis of axially oriented nanofibers, *J. Nanosci. Nanotechnol.*, 2015 (In Press).

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